PROC. BIOL. SOC. WASH.
94(3), 1981, pp. 774–786

OCCURRENCES OF SHRIMPS (NATANTIA: PENAEIDEA AND CARIDEA) IN CENTRAL CALIFORNIA AND OREGON

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Abstract.—Records are given for ten species of shrimps collected in central California and Oregon. These include six northern range records, one southern range record, and three intermediate occurrences. Particularly noteworthy are the new localities and observations reported for the freshwater shrimp, *Syncaris pacifica,* and the estuarine shrimp, *Palaemon macrodactylus*. Some of the northern range records may represent temporary range expansions that are established by larvae recruited from the south during warm water periods.

The shrimps of California were last reviewed comprehensively by Schmitt (1921). Since then, most workers have focused on specific taxa (Chace, 1951; Hart, 1964; Wicksten, 1977, 1978). Crossing taxa in this paper, I report new range records and other occurrences for ten species of Penaeidea and Caridea.

The records are based on my own collections, on those of some colleagues, and on certain museum material that came to my attention. In no case were any museum holdings examined exhaustively. Specimens are lodged in the California Academy of Sciences (CAS), the Moss Landing Marine Laboratory (MLML), the National Museum of Natural History (USNM), and the Allan Hancock Foundation (AHF).

Suborder Natantia
Section Penaeidea
Family Penaeidae
Subfamily Penaeinae

Penaeus (*Farfantepenaeus*) *californiensis* Holmes, 1900

Penaeus canaliculatus Holmes, 1895:581.

Penaeus californiensis Holmes, 1900:218, pl. 4, figs. 64–69.—Burkenroad, 1938:67, figs. 10–11 & 14–15.—Brusca, 1973:218, fig. 7.29.—Palacios, 1968:341, figs. 5–6.—Word & Charwat, 1976:17.—Edwards, 1978:151.—Holthuis, 1980:39.

Penaeus brevirostris.—in part, Rathbun, 1902a:287; 1904:146.—Schmitt, 1921:21, fig. 9.—Burkenroad, 1934:91.

Penaeus brasiliensis.—in part, Schmitt, 1935:16.
Penaeus californicus.—Carlisle, 1969:239.

Previous records.—PERU: Off Paita (Holthuis, 1980). MEXICO: Concepcion Bay, Baja California, 1926; Angeles Bay, Baja California, 1926, 31–42 m; and Lagunaje de las Lomitas, Esquinapa, Sinaloa, 1919 (Burkenroad, 1938). Off the west coast of Mexico, from Puerto Peñasco to Salina Cruz (Edwards, 1978). CALIFORNIA, USA: Off Anaheim and San Francisco Bay (Holmes, 1895). Off San Diego (Rathbun, 1902a). Off Santa Monica (Burkenroad, 1938). Santa Monica Bay (Carlisle, 1969). Off Oxnard, 21 m, and off Palos Verdes, 10 m (Word & Charwat, 1976).

Material examined.—CALIFORNIA, USA: Elkhorn Slough, near Red House and in Rubis Creek, Monterey Bay, 14 June 1978 and 8 May 1980, 2 specimens, MLML A0598 and Access. No. 024; Moss Landing Harbor, Monterey Bay, 27 December 1979–26 February 1980, 9 specimens, 7 ♂♂ (carapace lengths to orbit of 31–37 mm) and 2 ♀♀ (carapace lengths 45 and 53 mm), CAS 013366–013368, 013380, and 013384–013386; San Francisco Bay, central bay, near Potrero Power Plant, 23 May 1978, 1 ♀ specimen (length 42 mm), USNM 181206; San Francisco Bay, north bay, near China Camp, March 1980, 1 ♀ specimen (50 mm), CAS 013337.

Remarks.—These records are to the north of all previous ones, except for the two specimens recorded from San Francisco Bay by Holmes (1895). Thus, this shrimp would seem to be a rare visitor to San Francisco Bay. However, there was some incidental, sporadic fishing for this species in San Francisco Bay during the last century (Rathbun, 1883).

Penaeus californiensis is the most important commercial shrimp present in a fishery located along the Pacific coast of Mexico, especially in the Gulf of California, where it is trawled offshore and trapped or netted in coastal lagoons (Edwards, 1978). It is also fished in Central America and Ecuador (Holthuis, 1980). Recently, the shrimp has been the subject of aquaculture studies in Mexico (Edwards, 1978).

Section Caridea
Family Atyidae

Syncaris pacifica (Holmes, 1895)

Miersia pacifica Holmes, 1895:577, pl. 21, figs. 27–28.
Syncaris pacifica.—Holmes, 1900:213.—Hedgpeth, 1968:512, figs. 1–2; 1975:5, figs. 1–2.

Previous records.—CALIFORNIA, USA: Sonoma County (Holmes, 1895). Salmon Creek, Santa Rosa Creek, Atascadero Creek, and Blucher Creek, Sonoma County; Stemple Creek and Lagunitas (Papermill) Creek, Marin County; Napa River, near Calistoga, Napa County (Hedgpeth, 1968).

Salmon Creek and East Austin Creek, Sonoma County; and Lagunitas Creek, Marin County (Hedgpeth, 1975).

Material examined.—CALIFORNIA, USA: Lagunitas Creek, north of State Park at bridge, Marin County, 7 December 1979, 19 specimens, CAS 013379; Sonoma Creek, near Glen Ellen, Sonoma County, 15 September 1979 and 9 October 1979, 16 specimens, CAS 013369, 013378, 013382, and 013387; Huichica Creek, near highway 12-121 crossing, Napa County, 14 and 19 October 1979, 19 specimens, CAS 013370 and 013381.

Remarks.—The records from Sonoma and Huichica Creeks represent new drainage localities for this freshwater shrimp. In Sonoma Creek, they were found just south of Kenwood to somewhat north of Boyes Springs, a stream distance of about 11 km. An earlier effort to collect them downstream from these sites was unsuccessful (Hedgpeth, 1968). In Huichica Creek, located between Sonoma Creek and the Napa River, the shrimp was found only in one locality of one kilometer length and was most concentrated in a single deep pool.

My search extended, in the fall of 1979, to many other localities in Napa and southern Marin Counties. No shrimp were located in the Napa River or in any of its tributaries, although "promising" habitat was present in sections of Dry Creek. The last known collection from this area was taken in 1960 at Calistoga (L. Eng, California Department of Fish and Game, pers. comm.). Searching the streams in southern Marin County also proved fruitless, except for a well-known collecting site on Lagunitas Creek.

This shrimp is particularly interesting because of its limited distribution (parts of only three counties), sporadic occurrence, and specific habitat requirements. Hedgpeth (1968) has characterized the principal habitat of *Syncaris* as the warm, slower reaches of lowland streams. While this description is appropriate for some localities, observations at East Austin, Sonoma, and Huichica Creeks suggest a cool water habitat of deep continuously-flowing pools and fast-running shallow stretches. In pools the shrimp are usually located around eroded tree roots. In shallow stretches they find cover around the sedge *Cyperus eragrostis*.

Syncaris seems to be highly susceptible to man-caused habitat disturbances, perhaps having already become extinct in some streams (Hedgpeth, 1975). Human activities that may affect them include dredging, filling, and various kinds of pollution. To prevent the extinction of this species, Hedgpeth (1975) has advocated an endangered status for the shrimp, cessation of activities such as dredging, and rehabilitation of certain streams.

However, another man-caused disturbance may be at least as important as those noted above. *Syncaris* appears to be incapable of co-existing with introduced fish species, particularly centrarchids. Instead, the shrimp is almost always associated with native California fisheries, including salmonids. A similar observation has been made in Hawaii where atyid shrimps

seem to be incompatible with introduced mosquito fish (Edmondson, 1929). In California, some of the introduced fishes are also thought to be responsible for the local elimination of other, native fish species (Moyle, 1976a, b).

Syncaris is the only atyid shrimp remaining in western North America (Hedgpeth, 1975). Future efforts to protect this species should certainly consider the role of introduced fishes. Separating the effects of these fishes from other disturbance effects may prove challenging, however, because most introduced fishes themselves are found in disturbed habitats (Moyle, 1976b).

Family Palaemonidae
Subfamily Palaemoninae

Palaemon macrodactylus Rathbun, 1902b

Palaemon macrodactylus Rathbun, 1902b:52, fig. 24.—Balss, 1924:50.—Holthuis, 1950:7.—Newman, 1963:120, fig. 1.—Little, 1969:70, figs. 1–6.—Carlton, 1975:18; 1979:687.

Leander macrodactylus.—Parisi, 1919:76.—Kubo, 1942:36, figs. 7–9 & 19–30.

Leander serrifer longidactylus.—Yu, 1930:570, fig. 4.

Not *Leander macrodactylus*.—Yoshida, 1941:26, pl. 6, fig. 4 [=*Palaemon gravieri* (Yu)].

Previous records.—(Northeastern Pacific Ocean) CALIFORNIA, USA: San Francisco Bay (Newman, 1963; Little, 1969; Carlton & Kuris, 1975; Carlton, 1979). Los Angeles Harbor (Carlton, 1975; 1979).

Material examined.—CALIFORNIA, USA: Off Kirby Park, Dairy's, and Moss Landing Harbor, Elkhorn Slough, Monterey Bay, 11 April–18 October 1979, 58 larvae and 2 juveniles CAS 013389–013395.

Remarks.—The larvae of this species were identified from Little (1969). The record represents an important intermediate locality in California for the discontinuous distribution of this exotic species. Because this shrimp does not occur along the outer coast, it was probably transported to Elkhorn Slough rather recently from San Francisco Bay, either as fishing bait or possibly in water ballast.

Newman (1963) has suggested that *Palaemon* was introduced to San Francisco Bay in the early 1950's, by ships returning from Korea or Japan. In 1962 it appeared in the Los Angeles area (Carlton, 1979). The Los Angeles population may have been secondarily introduced from San Francisco Bay, or introduced directly from the western Pacific Ocean. The shrimp has also been introduced to Australia and is economically important in northern China and Japan (Holthuis, 1980).

Subfamily Pontoniinae

Pontonia californiensis Rathburn, 1902c

Pontonia californiensis Rathbun, 1902c:902; 1904:33, fig. 11.—Ritter, 1913:497.—Borradaile, 1917:391.—Schmitt, 1921:38, fig. 23.—Holthuis, 1951:145, pl. 46–47.—Word & Charwat, 1976:169.

Previous records.—CALIFORNIA, USA: Off Santa Cruz Island (34°00′N, 119°29′30″W), 55 m, 1889, *Albatross* Sta. 2945 (Rathbun, 1902c, 1904; Ritter, 1913). Off Santa Rosa Island, 27–29 m, 1941, 1940 Allan Hancock Expedition Sta. 1284-41 (Holthuis, 1951). Engels Bank, 26 m (Word & Charwat, 1976).

Material examined.—CALIFORNIA, USA: Off San Jose Creek Beach, Carmel (36°34′N, 121°56′W), 43 m, 2 October 1975, 1 specimen in the ascidian *Ascidia paratropa,* MLML A0539.

Remarks.—This specimen represents a northern range extension of 2°34′ in latitude and the first individual collected beyond the southern California bight.

The occurrence of only a few records for *Pontonia californiensis* suggests that these shrimp are either rare or cryptic, perhaps occurring as obligate symbionts with large solitary ascidians. Specimens have been collected from *Ascidia paratropa* (this record) and *A.* (=*Phallusia*) *vermiformis* (Ritter, 1913). Other Pontoniinae are associated with sponges, cnidarians, molluscs, echinoderms, and ascidians (Borradaile, 1917; Bruce, 1976).

Family Alpheidae

Synalpheus lockingtoni (Coutière, 1909)

Alpheus leviusculus Lockington, 1878:478.

Synalpheus lockingtoni.—Coutière, 1909:21, fig. 1.—Rathbun, 1910:606.—Schmitt, 1921:77, fig. 54 & pl. 12, fig. 1.—Carlton & Kuris, 1975:404.—Word & Charwat, 1976:63.

Not *Alpheus edwardsi leviusculus.*—Dana, 1852a:543, pl. 34, fig. 3a–f.

Previous records.—ECUADOR: Baia di S. Elena (Rathbun, 1910). BAJA CALIFORNIA, MEXICO: Off Puerto Escondido, off Puerto Mulege, and "other points" in the Gulf of California (Lockington, 1878). CALIFORNIA, USA: Off San Nicolas Island, 419–545 m, *Albatross* Sta. 4421 (Coutière, 1909). Off Venice Beach, Santa Monica Bay (33°59′N, 118°28′W), and west shore of Catalina Harbor, Santa Catalina Island, intertidal (Schmitt, 1921). Off Whites Point, Palos Verdes, intertidal, and San Diego Bay, intertidal (Word & Charwat, 1976).

Material examined.—CALIFORNIA, USA: Elkhorn Slough, Monterey Bay (36°52′N, 121°46′W), 18 July 1930, 1 specimen, collected by G. E. MacGinitie, CAS 013334.

Remarks.—This record represents a northern range extension of 2°53′ in latitude. The specimen referred to here has been mentioned previously (Carlton & Kuris, 1975, p. 404; J. T. Carlton, pers. comm.) but the data given therein were incomplete for establishing the record.

Family Hippolytidae

Heptacarpus brachydactylus (Rathbun, 1902c)

Spirontocaris brachydactyla Rathbun, 1902c:898; 1904:93, fig. 41.—Schmitt, 1921:72, fig. 48.
Heptacarpus brachydactylus.—Holthuis, 1947:12.—Word & Charwat, 1976:107.

Previous records.—CALIFORNIA, USA: Off Santa Cruz Island (34°00′N, 119°29′W), 486 m, *Albatross* Sta. 2948 (Rathbun, 1902c). Off San Diego, 763 m, *Albatross* Sta. 2928 (Rathbun, 1904).

Material examined.—CALIFORNIA, USA: Monterey Bay (36°45′N, 122°0′W), 576–695 m, 12 October 1973 and 14 August 1974, 3 specimens, MLML A0189 and A0493.

Remarks.—These specimens represent a northern range extension of 2°45′ in latitude and the first specimens collected beyond the southern California bight.

Heptacarpus decorus (Rathbun, 1902c)

Spirontocaris decora Rathbun, 1902c:896; 1904:79, fig. 33.—Schmitt, 1921:61, fig. 38.
Hippolyte decora.—Williamson, 1915:377.
Heptacarpus decorus.—Holthuis, 1947:12.—Word & Charwat, 1976:113.—Butler, 1980:214, pl. 7C.

Previous records.—BRITISH COLUMBIA, CANADA: Off Gabriola Island, Strait of Georgia, 91 m, 1961 (Butler, 1964, 1980). WASHINGTON, USA: Strait of Juan de Fuca, 278 and 208 m, *Albatross* Sta. 3454 and 3461; near Flattery Rocks, 313 m, *Albatross* Sta. 2866 (Rathbun, 1904). OREGON, USA: Heceta Bank, 91 m, *Albatross* Sta. 2886 (Rathbun, 1904). CALIFORNIA, USA: Off Santa Cruz Island, 274 m, *Albatross* Sta. 2946 (Rathbun, 1902c). Off Point Conception, 265 m, *Albatross* Sta. 2893; off Santa Rosa Island, 95 m, *Albatross* Sta. 2956; off San Diego, 227 m, *Albatross* Sta. 2935 (Rathbun, 1904). Off Palos Verdes Peninsula, 22 m; and off Dana Point, 87 m (Word & Charwat, 1976).

Material examined.—CALIFORNIA, USA: Monterey Bay, 128 m, 12 February 1931 and 9 March 1931, collected by G. E. MacGinitie, CAS 013429.

Remarks.—This record, an intermediate locality, provides further evi-

dence that the distribution of this species is continuous along the west coast of North America.

Lysmata californica (Stimpson, 1866)

Hippolysmata californica Stimpson, 1866:48; 1871:123.—Holmes, 1900:180, pl. 2, fig. 38.—Rathbun, 1904:56.—Schmitt, 1921:49, fig. 27.—Holthuis, 1947:19.—Limbaugh, *et al.*, 1961:249, fig. 7.—Ricketts & Calvin, 1968:144.

Hippolyte lineata.—Lockington, 1877:35.

Lysmata californica.—Chace, 1972:124.—Brusca, 1973:216, fig. 7.28.—Word & Charwat, 1976:145.

Previous records.—BAJA CALIFORNIA, MEXICO: Sebastion Viscaino Bay and Guadalupe Island (Limbaugh, *et al.*, 1961). Off Ensenada (Ricketts & Calvin, 1968). Off La Paz (Brusca, 1973). CALIFORNIA, USA: Off San Diego (Stimpson, 1866). Off Santa Catalina Island (Lockington, 1877). Off San Pedro, intertidal (Holmes, 1900). Off Santa Barbara (Rathbun, 1904). Off San Simeon (35°39′N, 121°11′W), intertidal; Los Angeles Harbor breakwater, 6 m; off Bunker Point, Palos Verdes, 6–12 m; and Lunada Bay, Palos Verdes, intertidal (Word & Charwat, 1976).

Material examined.—CALIFORNIA, USA: Monterey Bay, 20 June 1905, collected by G. E. MacGinitie, CAS 013427; Moss Landing Harbor, Monterey Bay, 27 February 1979 to 15 January 1980, 31 specimens, CAS 013383, 013388, and 013397–013402; off Coyote Point, south San Francisco Bay, 2 July 1977, 2 specimens, AHF 744-1; off Sacramento Landing, Tomales Bay (38°13′N, 122°54′W), August 1977, 4 specimens, CAS 013336.

Remarks.—All of the specimens studied here were collected to the north of the previous range record; the Tomales Bay locality is 2°34′ in latitude north of San Simeon.

Although Holmes (1900:181) states that the telson is "much shorter than the uropods," the specimens from Tomales Bay have the telson only subequal to the uropods.

This pen-striped shrimp is a facultative cleaning symbiont on certain large fishes and spiny lobsters (Limbaugh, *et al.*, 1961). It supports a small bait fishery located on the breakwater in San Pedro Bay, California, where it is known as the "red rock shrimp" (Turner & Sexsmith, 1965).

Spirontocaris lamellicornis (Dana, 1852)

Hippolyte lamellicornis Dana, 1852a:24; 1852b:576, pl. 36, fig. 6.—Williamson, 1915:330.

Spirontocaris lamellicornis.—Walker, 1898:277.—Holmes, 1900:208.—Rathbun, 1904:62, fig. 18.—Schmitt, 1921:53, fig. 29.—Holthuis, 1947:8.—

Word & Charwat, 1976:151.—Hayashi, 1977:158.—Butler, 1980:169, pl. 6D.

Previous records.—USSR: Off Commander (Komandorskie) Islands, Bering Sea (Rathbun, 1904). ALASKA, USA: Captains Harbor, Unalaska, 16 m; off Port Etches, 22–33 m; Sitka Harbor, 27 m (Rathbun, 1904). BRITISH COLUMBIA, CANADA: Gulf of Georgia, 123 m, *Albatross* Sta. 2863 (Rathbun, 1904). WASHINGTON, USA: Strait of Juan de Fuca, 97 m, *Albatross* Sta. 3460; Bellingham Bay, 20 m, *Albatross* Sta. 3612; off Destruction Island, 59 m, *Albatross* Sta. 2869; off Grays Harbor, 88–106 m, *Albatross* Sta. 2870 and 3046–3048 (Rathbun, 1904). Presidents Channel, Puget Sound, 192 m (Word & Charwat, 1976). OREGON, USA: Off Columbia River, 124 m, *Albatross* Sta. 2882; off Oregon 69–141 m, *Albatross* Sta. 3057–3059 (Rathbun, 1904). CALIFORNIA, USA: Off Point Arena (39°00′N, 123°49′W), 93 m, *Albatross* Sta. 3351 (Rathbun, 1904).

Material examined.—CALIFORNIA, USA: Monterey Bay, 128 m, 3 September 1931, collected by G. E. MacGinitie, CAS 013428; Santa Monica Bay (33°58′N, 118°36′W), 183–186 m, 28 July 1958, 6 specimens, AHF 892-02 (*fide* M. Wicksten).

Remarks.—All of the specimens recorded here were collected south of the previous range record; the Santa Monica Bay locality is 3°58′ in latitude south of Point Arena.

Family Crangonidae

Crangon (*Crangon*) *handi* Kuris & Carlton, 1977

Crangon handi Kuris & Carlton, 1977:543, figs. 1–2.

Previous records.—BAJA CALIFORNIA, MEXICO: Bahía Colnett (Kuris and Carlton, 1977). CALIFORNIA, USA: Off Shell Beach, Sonoma County (38°25′N, 123°6′W), and off other localities in southern Sonoma, Santa Cruz, Monterey, San Luis Obispo, and Orange Counties, including the Channel Islands, intertidal to 55 m (Kuris and Carlton, 1977).

Material examined.—OREGON, USA: North Cove, Cape Arago (43°29′N, 124°24′W), 17 August 1978, 1 juvenile specimen, CAS 019053.

Remarks.—This specimen extends the known northern range of this species by 5°04′ of latitude and represents the first record from Oregon.

Discussion

This paper adds new range records and occurrences to our knowledge of shrimp distributions in the northeastern Pacific. Among the species studied here, the distributions of *Pontonia californiensis* and *Heptacarpus brachydactylus* are based on only a few locality records (four and three, respec-

tively). The northern range limit is imperfectly known for *Crangon handi,* and possibly for *Heptacarpus decorus*. The southern range limits of *Synalpheus lockingtoni, Heptacarpus decorus, Lysmata californica,* and *Spirontocaris lamellicornis* are even less well documented. A more comprehensive review of shrimp biogeography would seem to require new collections and further study of existing museum holdings.

The most intriguing general pattern to emerge from this study concerns the five species having new northern range records in California: *Penaeus californiensis, Pontonia californiensis, Synalpheus lockingtoni, Heptacarpus brachydactylus,* and *Lysmata californica*. Previously, these species have been recorded mainly or entirely from localities south of Point Conception, California. It is now apparent that they sometimes occur in central California.

The records for these shrimps could represent previously unreported localities within their "normal" ranges. However, it is perhaps more likely that they reflect temporary range expansions, especially for the better-known species. If so, these shrimps were probably not members of reproducing northern populations. Instead, it is likely that they were migrants from southern California which were transported to the north as larvae.

The *Penaeus californiensis* specimens, for example, may have belonged to a single larval cohort, since they were all about the same size (except for sexual differences). They were also large enough to be several years old. Surface water temperatures taken at the Bodega Marine Laboratory show a warm period in the winter of 1976–1977. In that year temperatures averaged 12.5°C from November to February, while a ten year mean for these same months was only 11.1°C. The *Penaeus* could have been recruited to central California during this period.

The Davidson Current would seem to be the most likely larval transport mechanism for these temporary range expansions. This northward flowing surface current appears inshore and parallel to the southward flowing California Current in the winter (Pirie, *et al.,* 1975). It brings relatively warm, high salinity water close to shore and has been detected from Baja California to Vancouver Island. The strength of this current and the temperature of its water exhibit considerable variability, both within and between seasons. In central California, unusually warm winters have occurred in, but were not restricted to, the following years: 1858–59, 1925–26, 1929–31, 1936–37, 1940–41, 1957–60, 1969–70, 1976–77 (Skogsberg, 1936; Skogsberg and Phelps, 1946; Hubbs, 1948; Bolin and Abbott, 1963; Standing, personal observations). Hydrographic conditions that are favorable to temporary northern range expansions seem to occur at intervals of about five to ten years, sometimes recurring in consecutive years.

For most of these warm winters, there are crustacean examples of northern range expansions. The galatheid *Pleuroncodes planipes* was recorded

at localities to the north of its usual range off southern Baja California in 1859, 1941, 1957, 1959, and 1960 (Radovich, 1961), extending as far as San Francisco at least once (Holmes, 1900). In 1957–58 the euphausiids *Nyctiphanes simplex* and *Euphausia eximia* were collected north of their previously recorded ranges (Brinton, 1960). The former species is usually found south of Point Conception but was taken at Cape Mendocino in April 1958. The spiny lobster *Panulirus inflatus* is normally distributed in the Gulf of California and north to Magdalena Bay. However, specimens were collected at Guadalupe Island in 1948 and off San Diego in 1961 and 1962, perhaps arriving as larval recruits during warm periods (Fitch, 1962, 1963). Very extensive but temporary range expansions also include those for the hippid *Emerita analoga* and the portunid *Euphylax dovi*. The former species was recorded from Kodiak Island, Alaska in 1903 and from Vancouver Island, British Columbia in 1969 (Butler, 1959; Efford, 1969). The latter species has been collected in Santa Monica Bay and Monterey Bay (Word, 1976; Chivers, 1979). Zinsmeister (1974) gives examples of the same phenomenon for some mollusc species.

Acknowledgments

I am grateful to Debby Fishlyn Carlton, Brita Larsson, Arleen Navarret, and Johnson Wang for their help in collecting and organizing specimens. James Carlton, Dusty Chivers, Walt Dahlstrom, Dalene Ried, Larry Eng, Mike Kellogg, and Mary Wicksten provided records and other useful information, or assisted in museum work. Isabel Pérez Farfante confirmed my identification of *Penaeus californiensis*. James Carlton and Joe Goy commented on the manuscript. I sincerely thank all of these people.

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